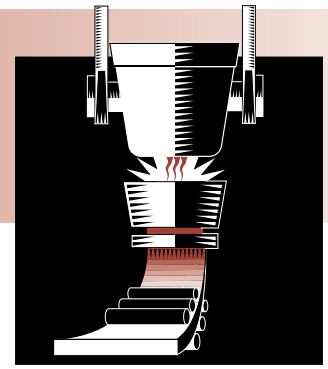


STEEL

Project Fact Sheet



ON-LINE, NON-DESTRUCTIVE MECHANICAL PROPERTIES MEASUREMENT USING LASER ULTRASONICS

BENEFITS

- Improved industrial competitiveness
- Energy savings of 1.2 trillion British thermal units (Btu) per year
- Added real-time product quality knowledge
- Improved mill yield
- Elimination of costly off-line testing
- Estimated annual cost savings of \$21 million
- Quality control along the entire length of the strips (which is presently an impossibility)
- Improved process control
- Improved customer satisfaction

APPLICATIONS

This sensor can be used to monitor mechanical properties in real-time along the entire length of steel sheets and other products. Plant trials, which include commercial partner support, are being conducted periodically at the steel partner plant site.

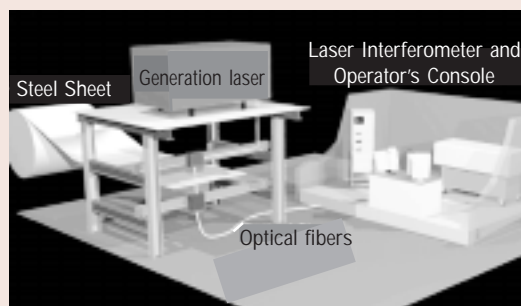
ON-LINE, NON-DESTRUCTIVE MECHANICAL PROPERTIES MEASUREMENT OF SHEET STEEL ALLOWS MEASUREMENTS USING LASER-GENERATED AND LASER-DETECTED ULTRASOUND

On-line, non-destructive mechanical properties measurement deals with the consistent production of large quantities of steel with well-controlled and uniform mechanical properties. An essential step in meeting this challenge is the development of reliable sensors to non-destructively monitor the mechanical properties of cold rolled steel on-line. The properties include: yield and tensile strength, elongation, and strain hardening values. Current determinations of mechanical properties are done off-line in costly and time-consuming destructive tests.

Laser-induced ultrasound is affected by microstructural parameters, such as grain size and crystallographic texture, which determine the mechanical properties of steel. This ultrasound is detected with a laser interferometer to record changes in ultrasonic velocities and amplitudes as a function of position along the entire length of the strip. These data are analyzed, and mechanical properties are inferred.

The technique is completely non-contact with standoff distances of over one foot. Sensing heads on a railing system permit scanning across the width of the sheet. On-line measurements made at LTV Steel Corporation indicate that ultimate tensile strength, plastic strain ratio, and microstructural features, as well as sheet thickness, can be readily measured.

LASER-ULTRASOUND PROTOTYPE



This laser-ultrasound prototype shows the laser used to generate the ultrasound on the top surface of the sheet and the fiber-optics coupled laser interferometer which detects the ultrasound on the opposite surface.



Project Description

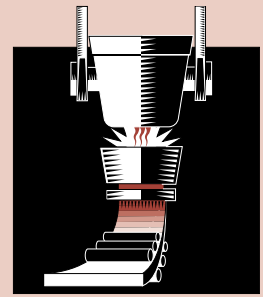
Goals: Develop a non-contact and non-destructive sensor to measure tensile properties such as: yield and ultimate tensile strength, uniform and total elongation, strain hardening exponent, and average plastic strain ratio of low carbon steel sheets at the exit of the production line.

More specific objectives are to:

1. Generate wideband ultrasound with a high-energy pulsed laser without damaging the surface to obtain a rich ultrasonic spectrum of information and better estimate grain size, crystallographic texture, and other microstructural parameters.
2. Establish model relationships between ultrasonic measurements and mechanical properties.
3. Establish the validity for mechanical property measurements for several chemistry grades over a range of processing conditions.
4. Explore the usefulness of the microstructural sensing technology to various processing stages such as hot rolling, controlled cooling, annealing, and skin pass.

Progress and Milestones

- In-plant measurements of mechanical properties (ultimate tensile strength, plastic strain ratio, and elongation), microstructure parameters (grain size and thickness), and sheet thickness have been demonstrated on low carbon and ultra low carbon grades.
- Microstructural variations along the full length and across the width of coils were observed. These variations were caused by usual processing practices.
- Real-time monitoring of microstructural kinetics such as grain growth, recovery, recrystallization, and phase transformations at high temperature have been demonstrated in real-time in a laboratory simulator.
- Additional capabilities are now being developed to improve yield strength measurements and to increase the signal to noise ratio while retaining operating conditions which preserve the surface appearance of the strip.



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